

Remarks

Claims 1-23 are pending, with claim 1 being independent. Claim 1 has been amended to even more clearly recite and distinctly claim the present invention. Claims 17 and 22 have been amended merely formally.

Applicants respectfully request the Examiner to withdraw the outstanding rejections in view of the foregoing amendments and the following remarks.

Claim Rejections under 35 U.S.C. § 103(a)

Claims 1, 9, 10, 12-18 and 20-22 are rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Tadashi (JP No. 2002-298919) in view of Gozdz et al. (US 5,552,239). Applicants respectfully disagree with this rejection; therefore, this rejection is traversed.

The present invention relates to a process for preparing an electrochemical device composed of a polyether/lithium salt electrolyte film between two films respectively constituting the positive electrode and the negative electrode. The process comprises assembling a multilayer structure comprising a current-collecting support, a film intended to form the positive electrode, a polyether film intended to form the electrolyte and a film intended to form the negative electrode, wherein:

- the film intended to form the positive electrode and/or the film intended to form the negative electrode are composed of a composite material comprising the lithium salt;
- the polyether film intended to form the electrolyte is ***prepared by extrusion*** and does not comprise lithium salt;
- the assembled device is left at rest for a time sufficient to allow the ***lithium salt*** present in the material of the positive electrode and/or in the material of the negative electrode ***to diffuse into the polymer film***.

As provided in the specification, electrochemical systems for energy storage, for example batteries or supercapacitors which operate with high cell voltages, require electrolytes which have a broad stability range. These electrolytes are obtained by dissolution of one or more ionic compounds in a polar liquid solvent, a solvating polymer, or mixtures thereof.

Also as provided, electrochemical systems in which the electrolyte comprises lithium salt and a polymer solvent of the polyether type are particularly advantageous. Such systems, which operate by circulation of lithium ions through an electrolyte between an anode and a cathode, can be composed of two electrodes in the form of films between which is the electrolyte, also in the film form. The multilayer assembly thus formed is rolled up. However, the preparation of such a device presents problems.

First, the lithium salts are hygroscopic and the preparation of the polyether material/lithium salt has to be carried out in an anhydrous atmosphere. Second and quite important, a polyether is a weakly crystalline polymer, which when blended with a lithium salt, forms a complex constituting a *sticky material*. For this reason, it is *quite difficult* to prepare a polyether material/lithium salt film *by extrusion*. To overcome this disadvantage, typically backing films have been used to prevent the polyether/lithium salt film from sticking to itself. However, when it is desired to remove the backing film, the strong adhesion between the backing film and the electrolytic film causes splits that render the electrolyte unusable.

According to the present invention, a polyether film *which does not comprise lithium salts* can be prepared by the conventional method of *extrusion*. This film can be protected by a backing film before its final use, and it is possible to detach the backing film from the polyether film without damage because of the low adhesion between the polyether and the backing film in the absence of lithium salts. The polyether film is then inserted between the anode and cathode films, at least one of which comprises lithium salt. The lithium salt present in the material of the anode and/or cathode diffuses into the polyether film (the electrolyte).

In contrast, Tadashi discloses a nonaqueous electrolyte battery, which can prevent the fall of the charge-and-discharge capacity by excess voltage arising in the charge and discharge in a high current. The battery of Tadashi comprises a cathode and an anode which are separated from each other by a separator. The cathode and the anode comprise an active electrode material and a gel-like polymer containing a lithium salt (designated by “non-aqueous electrolyte”). The separator between the cathode and the anode is impregnated with such a non-aqueous electrolyte.

At the time of assembly of the battery of Tadashi, the concentration of lithium salt in the non-aqueous electrolyte, which is contained in the anode and cathode, is higher than in the non-aqueous electrolyte that is impregnated in the separator. However, the separator is impregnated with a non-aqueous electrolyte containing lithium salt.

As described above, the presently claimed process prepares an electrochemical device composed of a polyether/lithium salt electrolyte film. As such, the electrolyte is a polymer electrolyte, which is a film of a material consisting of a salt dissolved in a polyether (which is a solvating polymer). The present process comprises assembling a film intended to form the positive electrode, a polyether film intended to form the electrolyte, and a film intended to form the negative electrode. Initially, only one or both of the films intended to form the electrodes contain a lithium salt. Lithium diffuses into the polyether film forming the electrolyte upon contact between the polyether film and the films forming the electrodes. As such, the element forming the electrolyte in the electrochemical cell of the present invention is a ***solid solution*** of a salt in a polymer. This film is formed ***by extrusion***. It is significantly different than a separator impregnated by a liquid or a polymer electrolyte, as disclosed in Tadashi.

Moreover, the separator of Tadashi is not prepared by extrusion. Because the separator in Tadashi is ***not prepared by extrusion***, there is no problem with the sticky character of the material intended to form the electrolyte.

Gozdz relates to a laminate compact rechargeable battery in which a separator/electrolyte is disposed between the electrodes. In Gozdz the different layers forming the battery are assembled together either by coating or by lamination. The separator/electrolyte is prepared by coating of a fluid composition on a solid support. (Col. 6, lines 41-52). According to the process of Gozdz, after assembly of the battery, it is compulsory to perform, first a step of impregnation of the cell with a lithium ion solution in order to introduce the lithium salt into the separator/electrolyte.

This step of impregnation with a lithium ion solution is significantly different from the phenomenon occurring in the presently claimed process in which lithium ions ***diffuse*** from one or both of the electrode materials into the polyether film because the polyether is a solvating polymer for the lithium ions. As such, in the present invention the lithium salt in the electrolyte is provided by one or both of the electrode compositions, without using any

additional composition or solvent containing lithium salt as required in Gozdz. Gozdz does not disclose or suggest the *lithium ions diffusing from the electrode materials into the polyether film*.

Moreover, Gozdz discloses active electrolytic components of the electrodes containing a lithium-ion intercalation material, such as a lithium metal oxide. (Col. 3, lines 9-19). These salts are active electrode materials and thus are suitable for the anode and cathode. However, they are not a lithium salt usable as an electrolyte. Accordingly, the lithium salts in the electrodes of Gozdz are distinguishable from the lithium salts in the electrolyte. In contrast, as described above in the present process, the lithium ions diffuse from one or both of the electrode materials into the polyether film of the electrolyte. Thus, the lithium salts in all are the same.

Therefore, even if combined Tadashi and Gozdz do not disclose the presently claimed process for the preparation of an electrochemical device composed of a polyether/lithium salt electrolyte film between two films respectively constituting the positive electrode and the negative electrode. Even if combined, Tadashi and Gozdz do not disclose or suggest assembling a multilayer structure comprising a current-collecting support, a film intended to form the positive electrode, a polyether film intended to form the electrolyte and a film intended to form the negative electrode, wherein the film intended to form the positive electrode and/or the film intended to form the negative electrode are composed of a composite material comprising the lithium salt; the polyether film intended to form the electrolyte is prepared by extrusion and does not comprise lithium salt, and the assembled device is left at rest for a time sufficient to allow the lithium salt present in the material of the positive electrode and/or in the material of the negative electrode to diffuse into the polymer film.

For at least the above noted reasons, Applicants respectfully submit that claims 1, 9, 10, 12-18, and 20-22 are not obvious over Tadashi in view of Gozdz and Applicants respectfully request withdrawal of this rejection.

Claim 2 is rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Tadashi in view of Gozdz et al. and further in view of Hayase (US 2002/298919). Applicants respectfully disagree with this rejection; therefore, this rejection is traversed.

Hayase relates to a chemical battery comprising a positive electrode, a negative electrode, and a gel electrolyte containing a crosslinked body and an electrolyte. The gel electrolyte is obtained from a gel electrolyte precursor. Hayase is cited merely for disclosing the thickness of the electrodes and electrolyte.

In the process of Hayase, the gel electrolyte used is obtained by a reticulation process from a gel electrolyte precursor containing a gelling agent (epoxy type polymer) and an electrolyte comprising a nonaqueous solvent and a lithium salt dissolved in the nonaqueous solvent. Accordingly, in Hayase the lithium salts are introduced in the electrolyte intended to separate the two electrodes during the preparation of the electrolyte layer, i.e., before the reticulation of the gelling agent, and therefore, before assembly of the battery.

As described in detail above, even if combined Tadashi and Gozdz do not disclose the presently claimed process for the preparation of an electrochemical device composed of a polyether/lithium salt electrolyte film between two films respectively constituting the positive electrode and the negative electrode. Even if combined, Tadashi and Gozdz do not disclose or suggest assembling a multilayer structure comprising a current-collecting support, a film intended to form the positive electrode, a polyether film intended to form the electrolyte and a film intended to form the negative electrode, wherein the film intended to form the positive electrode and/or the film intended to form the negative electrode are composed of a composite material comprising the lithium salt; the polyether film intended to form the electrolyte is prepared by extrusion and does not comprise lithium salt, and the assembled device is left at rest for a time sufficient to allow the lithium salt present in the material of the positive electrode and/or in the material of the negative electrode to diffuse into the polymer film.

Hayase as cited, and in its full disclosure, does not cure the many above-noted deficiencies in Tadashi and Gozdz. Accordingly, even if combined, Tadashi and Gozdz in view of Hayase do not disclose or suggest the presently claimed process.

Therefore, for at least the above noted reasons, Applicants respectfully request withdrawal of this rejection.

Claims 3-8, 19, and 23 are rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Tadashi in view of Gozdz et al. and further in view of Harvey (US

2004/0024174). Applicants respectfully disagree with this rejection; therefore, this rejection is traversed.

Harvey discloses a copolymer of ethylene oxide and at least one substituted oxirane carrying a cross-linkable function. Harvey is cited for disclosing copolymers obtained from ethylene oxide and from at least one substituted oxirane and which comprise at least 70% of CH₂-CH₂-O- repeat units derived from ethylene oxide.

In Harvey, the disclosed copolymer is useful for preparing solid electrolyte for batteries. Harvey discloses that when this copolymer is used to prepare an ionically conductive material (an electrolyte), it is associated with an ionic compound. The ionic compound, which can be a lithium salt, is introduced into the copolymer before the cross-linking or into the cross-linked polymer. (paragraph [0042]). In Harvey, the ionic compound can be incorporated into the copolymer by immersing the copolymer into a solution of the selected ionic compound and this ionically conductive material can thereafter be used as a solid polymer electrolyte to separate electrodes.

Therefore, according to Harvey the lithium ions are introduced into the electrolyte *before* the assembly of the battery. Moreover, in Harvey the ionically conductive material is poured onto a support after dissolution of the copolymer in a solvent and dried to evaporate the solvent and form a film (examples 4 and 6). Accordingly, the ionically conductive material is not prepared by extrusion.

As described in detail above, even if combined Tadashi and Gozdz do not disclose the presently claimed process for the preparation of an electrochemical device composed of a polyether/lithium salt electrolyte film between two films respectively constituting the positive electrode and the negative electrode. Even if combined, Tadashi and Gozdz do not disclose or suggest assembling a multilayer structure comprising a current-collecting support, a film intended to form the positive electrode, a polyether film intended to form the electrolyte and a film intended to form the negative electrode, wherein the film intended to form the positive electrode and/or the film intended to form the negative electrode are composed of a composite material comprising the lithium salt; the polyether film intended to form the electrolyte is prepared by extrusion and does not comprise lithium salt, and the assembled device is left at rest for a time sufficient to allow the lithium salt present in the material of the

positive electrode and/or in the material of the negative electrode to diffuse into the polymer film.

Harvey as cited, and in its full disclosure, does not cure the many above-noted deficiencies in Tadashi and Gozdz. Accordingly, even if combined, Tadashi and Gozdz in view of Harvey do not disclose or suggest the presently claimed process.

Therefore, for at least the above noted reasons, Applicants respectfully request withdrawal of this rejection.

Claim 11 is rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Tadashi in view of Gozdz et al. and further in view of Benson (US 2004/0023106). Applicants respectfully disagree with this rejection; therefore, this rejection is traversed.

Benson relates to an apparatus for use as an electrochemical device. The apparatus may be of particular use in the manufacture of thin-film, lightweight, flexible or conformable, electrochemical devices such as batteries and arrays of such devices. (paragraph [0003]). Benson is cited merely as disclosing that the film constituting the negative electrode is composed of lithium (i.e., as disclosing a lithium anode).

Benson relates to multi layer electrolyte systems, for example solid-state lithium batteries, including one or more inter-layers of lithium ion conducting materials interposed between two or more amorphous electrolyte layers. Benson discloses that such a multi-layer electrolyte system may prevent leakage and failure of thin-film batteries. Benson also does not disclose or suggest extrusion among the different techniques used to manufacture this multi-layer electrolyte system.

As described in detail above, even if combined Tadashi and Gozdz do not disclose the presently claimed process for the preparation of an electrochemical device composed of a polyether/lithium salt electrolyte film between two films respectively constituting the positive electrode and the negative electrode. Even if combined, Tadashi and Gozdz do not disclose or suggest assembling a multilayer structure comprising a current-collecting support, a film intended to form the positive electrode, a polyether film intended to form the electrolyte and a film intended to form the negative electrode, wherein the film intended to form the positive electrode and/or the film intended to form the negative electrode are composed of a composite material comprising the lithium salt; the polyether film intended to form the

electrolyte is prepared by extrusion and does not comprise lithium salt, and the assembled device is left at rest for a time sufficient to allow the lithium salt present in the material of the positive electrode and/or in the material of the negative electrode to diffuse into the polymer film.

Benson as cited, and in its full disclosure, does not cure the many above-noted deficiencies in Tadashi and Gozdz. Accordingly, even if combined, Tadashi and Gozdz in view of Benson do not disclose or suggest the presently claimed process.

Therefore, for at least the above noted reasons, Applicants respectfully request withdrawal of this rejection.

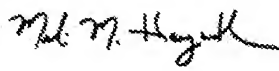
Conclusion

For at least the reasons noted above, the art of record does not disclose or suggest the inventive concept of the present claims.

In view of the foregoing amendments and remarks, reconsideration of the claims and allowance of the subject application is earnestly solicited. In the event that there are any questions relating to this response or the application, it would be appreciated if the Examiner would telephone the undersigned attorney.

If necessary for a timely response, this paper should be considered as a petition for an Extension of Time and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket # 104014.B130139).

Respectfully submitted,

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